The Feasibility of Using an Ultrasonic Fish Tracking System in the Tailrace of Lower Granite Dam

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We evaluated the feasibility of using an ultra-sonic fish tracking system in the tailrace of Lower Granite Dam from April 14 to June 7, 2002. The objectives of the study were to:

1. Evaluate the level of acoustic noise in the tailrace with specific regard to the frequencies used by the ultrasonic fish tracking system (UFTS).
2. Evaluate the performance of an UFTS in the tailrace by determining tag detectability, precision and accuracy of the positions, and tracking efficiency under varied project operations.
3. Track the path of juvenile salmon and passive particle drogues under varied spill treatments, to compare egress time and paths.
4. Track tagged juvenile salmon that were released by U.S. Geological Survey for the forebay testing of the removable spillway weir (RSW).

Given the tracking ability of the UFTS in the tailrace of Lower Granite Dam and the spacing of hydrophones, we determined that it was feasible to use an ultra-sonic fish tracking system in the tailrace of a hydroelectric dam. This technology is also sufficient to address research objectives that need 1-dimensional tracking information from tagged fish (75 m resolution). It is feasible that positions of fish could be resolved to within one meter (2D) if a hydrophone array were adequately spaced to account for reduced tag ranges due to the higher noise present in Lower Granite Dam tailrace in comparison to the forebay in the 200 to 450 kHz range.

Egress timing for juvenile salmon was divided into four treatments based on powerhouse and spill discharge (Table 1).

Table 1. Residence time of juvenile salmon as determined from first and last detections in the tailrace at Lower Granite Dam in the spring of 2002. Treatments were divided by the median operation of the spillway or powerhouse from April 14 to June 7, 2002. Low and high spill were divided at 24 Kcfs, and Low and high powerhouse operations were divided at 54 Kcfs.

Tailrace Condition	Fish Detected	Minimum residence	Median residence	Mean residence	Maximum residence

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	(N)	time (minutes)	time (minutes)	time (minutes)	time (minutes)
1) Low Spill, Low Powerhouse	30	0.1	9.0	35.3	385.3
2) Low Spill, High Powerhouse	14	0.4	1.4	81.1	1078
3) *High Spill, Low Powerhouse	27	0.2	61.2	133..4	605.9
4) High Spill, High Powerhouse	19	0.4	4.1	11.2	107.7

*Significantly different from the conditions 1 and 4 using t-test at 95% CL, log transformed data.

Residence times were significantly longer for the high spill, low powerhouse treatment than for treatments 1 and 4 (table 1). Additional data addressing tag detectability, and egress timing of juvenile salmon will be provided at AFEP.

Results from the noise testing of the tailrace offered insight into the performance of the UFTS for the spring of 2002. The noise, likely a product of operating turbines and spillway, limited the range of detection of the ultra-sonic tags. The detection range for tags was modeled using the relationship between tag signal degradation over range and the noise floor (signal to noise ratio). The range for tags was calculated to be 45 m in early April with a noise floor at 118 dB re: 1µPa for frequencies between 200 kHz and 450 kHz. By early June the noise floor had dropped to 102 dB re: 1µPa, which increased the calculated range of detection to 235 m. There were fewer operating turbines during this time period. Measured tag detection ranges varied from 15 m to 75 m and were dependent on spillway and powerhouse discharge. However, the UFTS was deployed in the same manner as it would be to track fish in the forebay of a dam. Hydrophones were spaced to encompass a volume that was 100 m to 130 m square and was bound above and below by the depth of the water. This spacing was not sufficient to position a fish in two or three dimensions due to range limitations (both modeled and measured) for the majority of the season. Given this scenario, we could detect tags but rarely could determine their exact positions, and were therefore limited to mostly 1-dimensional tracking.

Using 1-dimensional tracking we were able to detect 22% of tagged juvenile salmon that passed the forebay for the 3D tracking portion of the RSW tests. We determined the egress paths and timing of detected juvenile salmon based on location of hydrophones and the proximity of a tagged fish to a hydrophone. Hydrophones were sufficiently spaced in the tailrace from the dam face and downstream to the tip of the navigation guide wall, which allowed for tag detection in areas throughout the tailrace. Egress timing of juvenile salmon was then compared to project operations, based the detection of tagged fish within this area. Lower Granite Dam project operations were variable throughout the tests of the Removable Spillway Weir, and did not adhere to the planned high-low spill patterns that would accompany RSW operation. Due to these circumstances, we divided our data for the spring research season into four project operation treatments based on the median of spill discharge (median = 24 Kcfs) and the median of powerhouse discharge (median = 54 Kcfs, table 1).